Near-infrared variability in dusty white dwarfs: tracing the accretion of planetary material

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Exoplanetary material ends up in the atmosphere of 25-50% of single white dwarfs, the remnant core of a star. We aim to understand the puzzle of how this material gets from the outer region of the planetary system and into the atmosphere of the white dwarf. We study the dust that lies in a reservoir close to these white dwarfs; this material subsequently accretes onto the white dwarf. We used the United Kingdom Infra-Red Telescope to systematically monitor the brightness of the dust around 34 white dwarfs over 3 years. We constrain how variable the dust is for these systems and thus improve the understanding of how exoplanetary material ultimately ends up in the atmosphere of white dwarfs.

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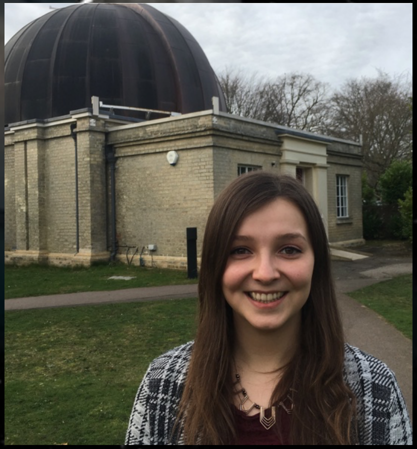

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What is a dusty white dwarf?

White dwarfs are the end product of stellar evolution.

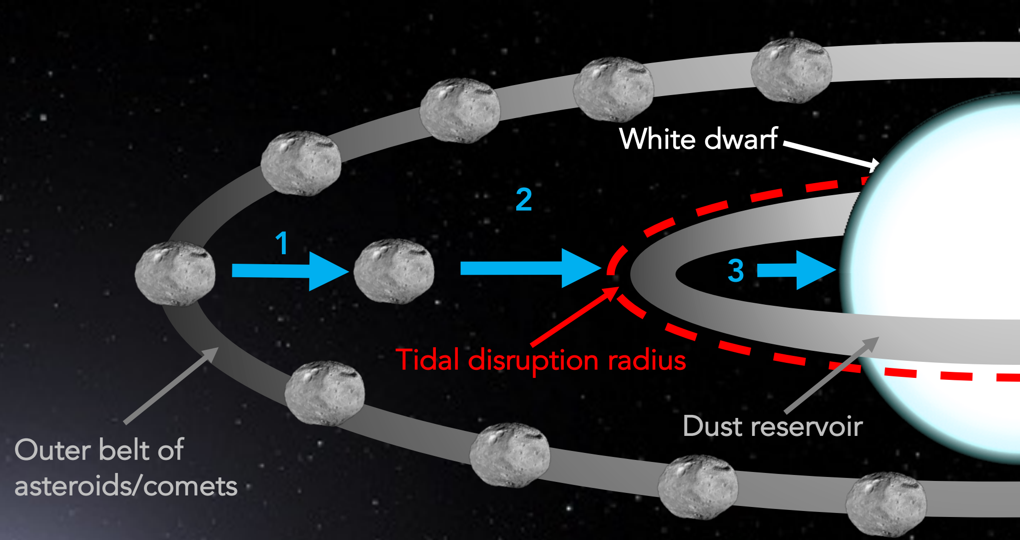
Planetary systems can survive to the white dwarf phase.

Chunks of planetary material from the outer belts get perturbed towards the white dwarf (see diagram arrow - 1).

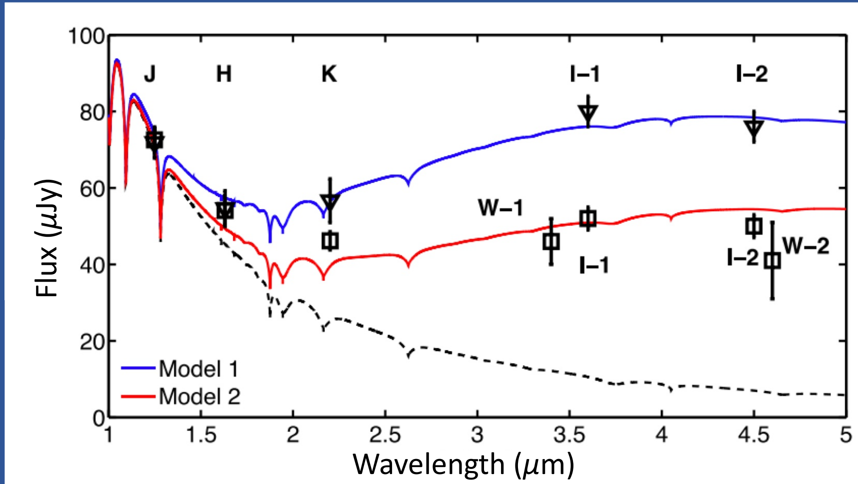
Due to the strong gravitational field of white dwarfs, the material gets torn apart and forms a circumstellar dust reservoir (2) – these are dusty white dwarfs.

This material then accretes onto the atmosphere of the white dwarf (3).

The only way to directly study the bulk chemical composition of an exoplanetary body is to observe these white dwarfs which have accreted planetary material.



See a short animation at: https://youtu.be/pEzRaIcNc10



A dusty white dwarf displaying a significant drop in the infrared dust flux, where the ▼ points show the initial flux and the ■ points show the dropped flux ~ 1 year later (Xu & Jura, 2014).

How does the material get there?

We study dusty white dwarfs to:

A. Understand how the material gets from the dust reservoir to the atmosphere of the white dwarf (arrow 3).

- ➢ Is the accretion a steady flow? What processes contribute to this accretion?

B. Understand whether it is one body or multiple bodies.

- ➢ Is it one body letting out a steady stream of material? Or is it many bodies? If the latter, is it a steady disc or stochastic (random) with highly variable accretion from the scattering and disruption of many bodies?

Xu & Jura (2014) discovered the first dusty white dwarf which showed large amounts of dust variability, shown left. To answer the questions above we need to study a larger sample.

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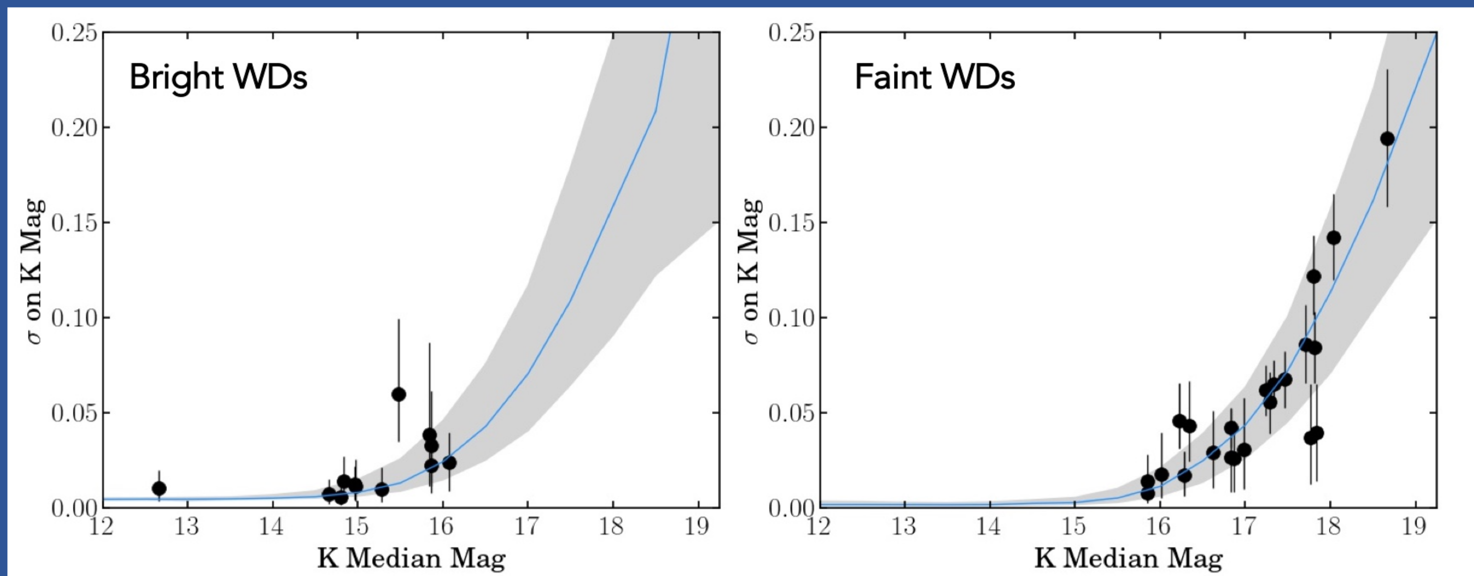
Near-Infrared monitoring campaign of dusty white dwarfs

Project: We monitored 34 dusty white dwarfs with the United Kingdom Infra-Red Telescope in the near-infrared (J, H and K) photometric bands from 2014 to 2017.

Aim: By looking at how the brightness of the dust changes over time, we aim to discover whether the dust was stable or if it varied in the near-infrared, and therefore what this can tell us about how the exoplanetary material got into the atmosphere of the white dwarf.

We take all the brightness measurements from our monitoring campaign and for each object find the best fitting median magnitude (how bright the object is) and standard deviation (σ), which we take as a proxy for the variability.

The figure below shows the expected 'variability' as a function of magnitude for non-variable field stars (blue line and grey contour – which is the error on the blue line) and the white dwarfs (black points).



None of the values of the white dwarfs' variability (σ) lie significantly above that expected from non-variable field stars (blue line). Therefore, for all 34 dusty white dwarfs, the near-infrared dust flux appears stable within the error of the survey.

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Take home message:

We aim to understand how planetary material arrives in the atmosphere of white dwarfs. This understanding is key to using polluted white dwarf systems to uncover the composition of material in exoplanetary systems.

We believe that the accretion process should be highly stochastic, where asteroids are randomly scattered in. There is evidence for large variability in infrared emission for some white dwarfs accreting planetary material. These were often found 'by chance'.

We systematically monitor 34 dusty white dwarfs for 3 years and see no evidence for large variability - the accretion appears stable and the tidal disruption events which lead to large variabilities are rare and occur on longer timescales.

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